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Are fluctuations in electricity consumption per capita transitory? Evidence from developed and developing economies

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ABSTRACT

This paper investigates the unit root properties of electricity consumption per capita of 67 developed and developing countries for the period 1971–2010. To examine the stationary properties of electricity consumption per capita, we have adopted Lee and Strazicich (2003, 2004) test of unit root that allows us to test for at most two endogenous breaks and uses the Lagrange Multiplier (LM) test statistics. Results show that 65 country series reject the unit root null hypothesis except for 2 country series. Thus, our empirical findings provide significant evidence that electricity consumption per capita is stationary in almost all countries considered. The stationarity of electricity consumption per capita indicates that it should be possible for the series to forecast future movements in the energy consumption based on the past behaviors of the series.

Contents

1. Introduction

Energy literature seems to provide the empirical evidence finding stationarity properties of energy consumption. For instance, Lee and Chang [1], Al-Irani [2], Chen and Lee [3], Narayan and Smyth [4], Hsu et al. [5], Lean and Smyth [6], Mishra et al. [7], Apergis et al. [8,9], Narayan et al. [10], Ozturk and Aslan [11], Hasanov and Telatar [12], Aslan [13], Aslan and Kum [14] and Kula et al. [15] applied numerous approaches to examine stationarity properties of energy consumption. The empirical investigation of stationarity properties of the energy consumption leads us to check whether shocks to energy consumption have unending or temporary effects. If the series of energy consumption is stationary at level then fluctuations in energy consumption will have temporary effects with the passage of time and such economic policies have transitory impact. These effects are removed once the series (i.e. energy consumption) return to their long run path. The past behavior of energy consumption can be used to formulate forecast once series is found to be stationary. On the contrary; if energy consumption contains a unit root problem (i.e. non-stationary) then fluctuations in energy consumption seem to have permanent effects (Chen and Lee, [3]; Mishra et al., [7]).

The studies reported in Table 1 applied various techniques to find stationarity properties of energy variables providing conflicting results. Most of these studies used unit root tests which do not have information about structural break point stemming in the energy series except Ozturk and Aslan [11] and Kula et al. [15]. These tests failed to capture the effects of continuous economic growth, implementation of national policies, crisis, wars etc, although authors employed a variety of econometric approaches. Thus, when structural breaks are taken into account, most of the studies show that electricity consumption per capita is stationary.

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Table 1
Survey of literature for stationarity properties.

Authors	Time period	Unit root test	Conclusion
Lee and Chang [1]	1954–2003	Zivot and Andrews [16] structural break test	Unit root exists
Al-Iriani [2]	1971–2002	Univariate and IPS panel tests	Unit root exists
Narayan and Smyth [4]	1979–2000	Univariate and IPS panel tests	Stationarity is found
Chen and Lee [3]	1971–2000	Carrion-Silvestre multiple Test	Stationarity is found
Narayan et al. [17]	1973–2008	LM structural break test	Stationarity is found
Hsu et al. [5]	1971–2003	Panel seemingly unrelated regressions ADF	Unit root exists
Mishra et al. [7]	1980–2005	LLC, IPS and Maddalae Wu (MW) panel tests and CIPS test	Miscellaneous results
Lean and Smyth [6]	1973–2008	Long memory test	Miscellaneous results
Narayan et al. [10]	1973–2007	Lee and Strazicich [18) two Structural break Test	Stationarity is found
Apergis et al. [8]	1982–2007	LM structural break test	Stationarity is found
Apergis et al. [9]	1980–2007	LM structural break test	Stationarity is found
Ozturk and Aslan [11]	1970–2006	Lee and Strazicich [18]) two Structural break Test	Stationarity is found
Hasanov and Telatar [12]	1980–2006	Non-linear Test by Kapetanios et al. [19]	Miscellaneous results
Aslan [11]	1960–2008	LM structural break test	Miscellaneous results
Aslan and Kum [14]	1970–2006	LM structural break test	Stationarity is found
Kula et al. [15]	1960–2005	LM structural break test	Stationarity is found

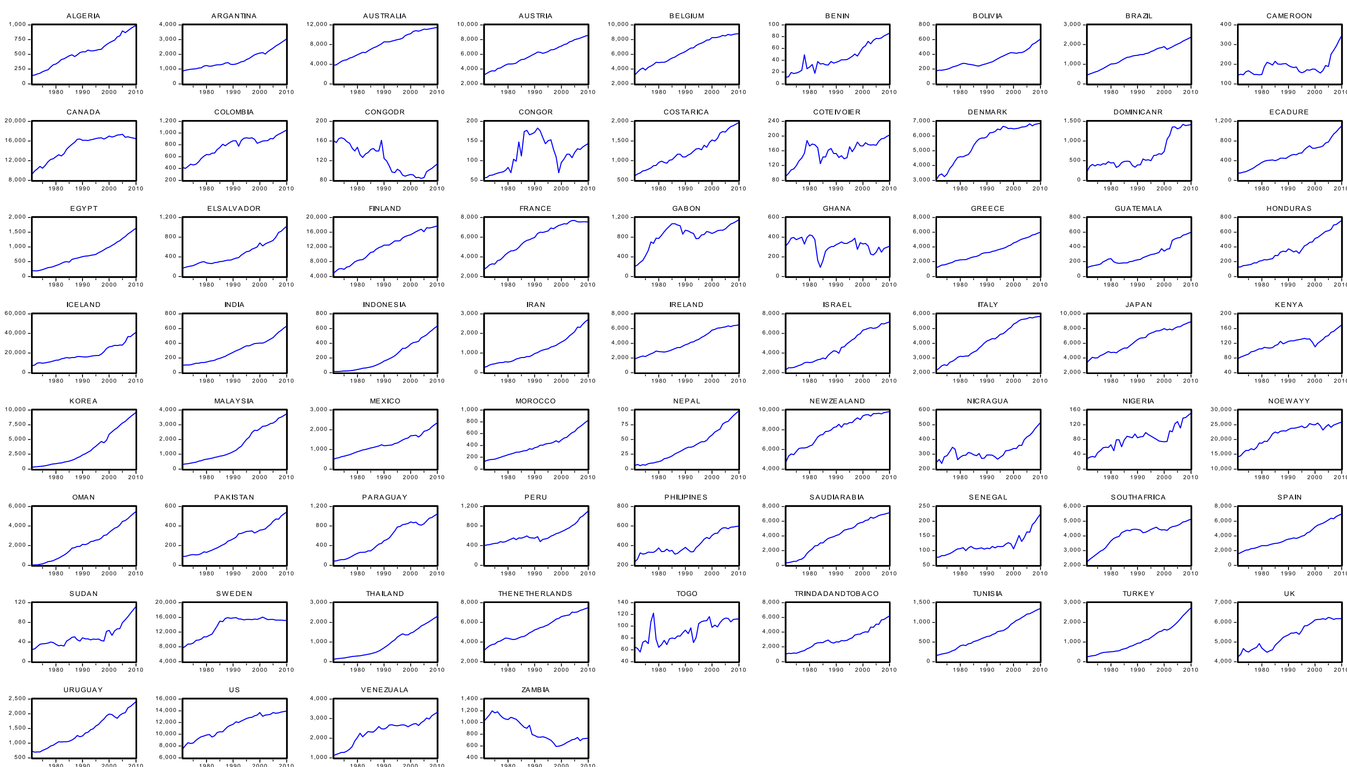

Fig. 1. Electricity consumption per capita in sample countries.

Finally, by taking structural breaks in the electricity consumption series will significantly increase the power of the unit root tests and more significant results may be obtained from the analyses.

The aim of this paper is to examine the unit root properties of electricity consumption per capita for the 67 developed and developing countries for 1971–2010 period (see Fig. 1). The paper is organized as follows: Section 2 describes methodology and data. Section 3 presents results and Section 4 concludes the paper.

2. Methodology and data

Traditional unit root tests like Augmented Dickey Fuller (ADF) [20], Phillips–Perron (PP) [21] and Perron [22] are found to give misleading results (i.e. biased towards the non-rejection of null hypothesis when structural breaks are present in the data series). Therefore, in the present study we have adopted Lee and Strazicich [18,23] test of unit root that allows us to test for at most two endogenous break and uses the Lagrange Multiplier (LM) test statistics. Let us consider the following data generating process (DGP):

$$y = \delta Z_t + e_{t,}, \; e_t = \beta e_{t-1} + \varepsilon_t. \qquad (1)$$

where Z_t is a vector of exogenous variables, δ is a vector of parameters and ε_t is a white noise process, such that $\varepsilon_t \sim NIID(0, \sigma^2)$. First we will consider the case where there is evidence of one structural break. The crash model that allows shift in level only is described by $Z_t = [1, t, D_t]'$, and the break model that allows for changes in both level and trend is described as

$Z_t = [1, t, D_t, DT_t]'$,where D_t and DT_t are two dummies defined as:

$D_t = 1$, if $t \geq T_B + 1 = 0$, otherwise and $DT_t = t - T_B$,
if $t \geq T_B + 1 = 0$, otherwise

where T_B is the time period of the break date.

Next, let us consider the framework that allows for two structural breaks. The crash model that considers two shifts in level only is described by $Z_t = [1, t, D_{1t}, D_{2t}]'$, and the break model that allows for two changes in both level and trend is described as $Z_t = [1, t, D_{1t}, DT_{1t}, D_{2t}, DT_{2t}]'$, where D_{jt} and DT_{jt} for j=1, 2 are appropriate dummies defined as above, viz., $D_{jt} = 1, \quad \text{if} t \geq T_{Bj} + 1 = 0$, otherwise and $DT_{jt} = t - T_{Bj}, \quad \text{if} t \geq T_{Bj} + 1 = 0$, otherwise where T_{Bj} is the jth break date.

The main advantage of the (Lee and Strazicich, [18,23]) approach to unit root test is that it allows for breaks under the null (β=1) and alternative (β < 1) in the DGP given in Eq. (1). This method uses the following regression to obtain the LM unit root test statistics.

$$\Delta y_t = \delta' \Delta Z_t + \phi \tilde{S}_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta \tilde{S}_{t-j} + u_t \tag{2}$$

where $\tilde{S}_t = y_t - \tilde{\Psi}_t - Z_t \tilde{\delta}, t = 2, \ldots, T; \tilde{\delta}$ denotes the regression coefficient of Δy_t on ΔZ_t and $\tilde{\Psi}_t = y_t - Z_1 \tilde{\delta}, y_1$ and Z_1 being first observations of y_t and Z_t, respectively. The lagged term $\Delta \tilde{S}_{t-j}$is included to correct for likely serial correlation in errors and j indexes lagged values of error correction term. Using the above equation, the null hypothesis of unit root test ($\phi = 0$) is tested by the LM t-statistics. The location of the structural break or structural breaks is determined by selecting all possible breaks for the minimum t-statistic as follows:

$\ln f \tilde{\tau}(\overline{\lambda}_i) = \ln_{\lambda} f \tilde{\tau}(\lambda)$, where $\lambda = T_B/T$

The search is carried out over the trimming region (0.15T, 0.85T), where T is sample size and T_B denotes date of structural break. We determined the breaks where the endogenous two-break LM t-test statistic is at a minimum. The critical values are tabulated in Lee and Strazicich [18,23] for the two-break and one-break cases, respectively.

The data on electricity consumption per capita (kW h) has been obtained from World Bank′s World Development Indicators (WDI-CD, 2012). We have used data of 67 developed and developing countries for 1971–2010 period (see Table 2 for the countries used in this study). These countries are selected according to data availability.

3. Empirical results

We start our empirical exercise by examining stationarity properties of electricity consumption per capita applying univariate LM unit root test with two structural breaks of 67 developed and developing economies of the globe. We decided to use maximum number of lagged augmented terms that is k=12. As such, the procedure looks for the significance of the last augmented term. We then use the 10% asymptotic normal value of 1.645 on the t-statistic of the last first differenced lagged term. After determining the optimal k at each combination of two break points, we determine the structural breaks where the endogenous two breaks LM t-test statistic is at a minimum. We examine each possible combination of two break points over the time interval of (0.15T, 0.85T) while eliminating the endpoints. Here, T is the sample of size. We begin with the LM unit root t-statistic with two breaks and examine the significance of the dummy coefficients on the basis of the conventional t-statistics. If less than two breaks are significant at 10%, we apply the minimum LM unit root

Table 2
LM unit root test with two structural breaks.

No.	Countries	T_{B1}	T_{B2}	T statistics	k
1	Algeria	1986	2005	−7.955*	12
2	Argentina	1987	1996	−9.791*	5
3	Australia	1986	–	−2.1204	0
4	Austria	1990	2005	−12.637*	12
5	Belgium	1987	1991	−7.481*	12
6	Benin	1985	1999	−5.565*	0
7	Bolivia	1990	1999	−7.819*	7
8	Brazil	1988	1999	−4.946*	12
9	Cameroon	1987	2001	−4.808*	11
10	Canada	1987	1997	−8.226*	12
11	Colombia	1991	2001	−4.935*	4
12	Congo Dem. Rep.	1986	1988	−11.786*	12
13	Congo Rep.	1993	2003	−8.183*	12
14	Sweden	1993	1996	−8.071*	12
15	Costa Rica	1992	2000	−8.871*	11
16	Ivory Coast	1987	1994	−10.579*	0
17	Denmark	1987	2002	−6.585*	10
18	Dominican Rep.	1987	1999	−7.312*	12
19	Ecuador	1993	1998	−4.187**	10
20	Egypt	1991	1997	−9.359*	12
21	El-Salvador	1987	1995	−7.949*	10
22	Finland	1985	1997	−6.776*	7
23	France	1986	1991	−6.985*	11
24	Gabon	1990	1999	−5.841*	11
25	Ghana	1991	2002	−10.337*	8
26	Greece	1988	1999	−4.495**	1
27	Guatemala	1997	2002	−6.332*	10
28	Honduras	1990	1998	−6.010*	3
29	Iceland	1988	1996	−7.030*	4
30	India	1986	2000	−7.024*	7
31	Indonesia	1989	1996	−5.164*	1
32	Iran	1988	1995	−7.927*	10
33	Ireland	1998	2005	−7.636*	11
34	Israel	1985	1991	−5.091*	2
35	Italy	1991	2000	−9.961*	6
36	Japan	1985	1999	−7.296*	8
37	Kenya	1986	1998	−13.842*	12
38	Korea Dem. Rep.	1996	2000	−7.029*	1
39	Malaysia	1989	1997	−6.260*	7
40	Mexico	1987	2001	−8.828*	12
41	Morocco	1985	1998	−4.793*	0
42	Nepal	1988	1992	−7.925*	12
43	The Netherlands	1992	1995	−7.749*	12
44	New Zealand	1985	2002	−4.918*	0
45	Nicaragua	1986	2002	−8.251*	10
46	Nigeria	1988	2000	−7.275*	5
47	Norway	1988	1992	−9.076*	11
48	Oman	1990	2001	−4.445*	12
49	Pakistan	1993	2000	−6.221*	11
50	Paraguay	1985	1990	−8.527*	7
51	Peru	1986	1993	−5.759*	0
52	Philippines	1988	1990	−6.878*	10
53	Serbia	1986	–	−1.4872	5
54	Senegal	1998	2002	−9.098*	11
55	South Africa	1996	2002	−11.321*	10
56	Spain	1986	1991	−10.921*	12
57	Sudan	1991	1997	−6.226*	6
58	Thailand	1991	1996	−7.453*	11
59	Togo	1992	1998	−6.850*	8
60	Trinidad and Tobago	1987	–	−3.7263**	8
61	Tunisia	1991	2004	−4.457**	9
62	Turkey	1992	1997	−4.617*	6
63	United Kingdom	1985	1994	−12.984*	10
64	Uruguay	1989	2001	−4.556*	0
65	United States	1994	1999	−7.227*	12
66	Venezuela	1988	2003	−7.624*	6
67	Zambia	1987	1998	−6.651*	4

Note: This table presents results for univariate LM unit root test with two structural breaks in intercept/constant and trend both. T_{B1} and T_{B2} are the dates of the structural breaks; k is the lag length that is the optimal number of lagged first differenced terms included in the unit root test to correct for serial correlation. The 1%, 5% and 10% critical values for the minimum LM test with one break are −4.239, −3.566 and −3.211, respectively. The 1%, 5% and 10% critical values for the minimum LM test with two breaks are −4.545, −3.842 and −3.504, respectively. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

t-statistic with one break proposed by Lee and Strazicich [23]. The LM unit root test results for per capita electricity consumption series are summarized in Table 2.

The LM unit root analysis summarized in Table 2 provides support to accept the stationarity hypothesis of electricity consumption per capita series for 65 of selected 67 developed and developing countries. The results confirm that fluctuations in electricity consumption have temporary effects in 65 countries. Kula et al. [15] conducted a study using data of OECD countries and concluded that in case of Finland and Spain shocks to electricity consumption per capita are permanent. We found that shocks to electricity consumption per capita are permanent for Australia and Serbia. Further, our findings regarding Finland and Spain are not consistent with Kula et al. [15] because our analysis reveals that shocks to electricity consumption per capita have permanent effects in case of Finland and Spain. The reason might be the span of the data used for analysis where Kula et al. [15] utilized data for the period 1960–2005 and this study used data covering period 1971–2010. An examination of the break points in Table 2 reveals some clustering of the break dates. It is apparent that first structural breaks in most of the series had occurred which indicated the fall oil prices from US$ 35 per barrel in 1980 to US$ 27 per barrel in 1986 that affected the world economic activity. The second type structural break in electricity consumption can be linked to global financial crisis which in resulting affected economic activity and hence electricity demand in these countries. The third structural break relates to Asian financial crisis occurred in 1997.

This implies that the preponderance of break points reflected recessions during this period which led to large shifts in economic activity and hence electricity demand.

4. Conclusion and future research

The stationary properties of per capita electricity consumption have been analyzed in this study for 67 developed and developing countries by using (time series data) annual data over 1971–2010. LM unit root test has been applied that endogenously determines structural breaks in level and trend. Empirical results of the unit root test reveal that 65 country series reject the unit root null hypothesis at the 1% and 5% significance levels, and accept only in 2 country series (in Australia and Serbia). Hence, on the basis of empirical evidences investigated in this paper, we can say that per capita electricity consumption is stationary in almost all the countries. Thus, if the per capita electricity consumption is mean (or trend) reverting, then it follows that the series will return to its mean value (or trend path) and it might be possible to forecast future movements in the per capita electricity consumption based on past behaviors of the series (Narayan and Smyth, [4]).

For the policy makers, it is not necessary to pay attention to electricity consumption series. For the future studies related with electricity consumption, structural breaks should be taken into account to obtain more significant results. Future research should consider sectoral data level such as industrial electricity and/or residential electricity rather than aggregate data.

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